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1 APRIL 1977 - 30 JUNE 1977

(15) CONTRACT DAAB07-76-C-0041

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MANUFACTURING METHODS AND TECHNIQUES FOR MINIATURE HIGH VOLTAGE HYBRID MULTIPLIER MODULES.

PLACED BY:

PROCUREMENT & PRODUCTION DIRECTORATE

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The design of the curved and rectangular capacitor banks was finalized, the coating techniques developed and the choice of the lead material and attachment technique made.

Rectangular and curved multipliers were fabricated for the First Engineering Sample.

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FOURTH QUARTERLY PROGRESS REPORT

1 APRIL 1977 TO 30 JUNE 1977

MANUFACTURING METHODS AND TECHNIQUES FOR MINIATURE HIGH VOLTAGE HYBRID MULTIPLIER MODULES

CONTRACT NO. DAAB07-76-C-0041

PREPARED BY: DR. MICHAEL KORWIN-PAWLOWSKI

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ABSTRACT

The progress made during the fourth quarter of work on the Manufacturing and Technology Program for Miniature High Voltage Multiplier Modules is described in this report.

During this period the design of the curved and rectangular capacitor banks was finalized, the coating techniques developed, and the choice of the lead material and attachment technique made.

Rectangular and curved multipliers were fabricated for the First Engineering Sample.

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PURPOSE

This Contract covers component designs, mounting and interconnection techniques, tooling and test methods and other manufacturing methods and techniques required for production of rectangular and curved miniature high voltage multiplier modules. These units are to be used in low cost power supplies for second generation image intensifier tubes. The full scope and details of the specification are given in SCS-495, Appendix A to the First Quarterly Report.

Major milestones in this program consist of delivery of the following items:

(1) First and second engineering samples and test data.

(2) Production line layout and schedule.

(3) Confirmatory samples and test data.

(4) Production line set-up.

(5) Pilot production run.

(6) Production rate demonstration.

(7) Preparation and publication of a final report.

The general approach is to design and set-up a cost-effective production capability, utilizing already established device technologies and materials, and to demonstrate the production line capability to fabricate at the rate of 125 acceptable units per 40 hour week.

GLOSSARY OF SPECIAL TERMS

Capacitor bank:	- Ceramic wafer with metallizations which perform the function of a number of capacitors connected in parallel (parallel bank) or in series (series capacitor bank).
Cure:	- To change the physical properties of a material by chemical reaction or by the action of heat and catalyst.
Flash test:	- Test consisting of instantaneous application of voltage at its specified value to the part.
Hybrid:	- Technology combining thick-films (capacitor banks) with discrete devices (rectifiers).
Multiplier modules:	- Device consisting of capacitor banks and rectifiers connected and packaged to perform voltage multiplication and rectification.
Pad:	- The metallized area on the cermaic bank acting as a plate of a capacitor and used to make an electrical connection to it.
Rectifier:	- Semiconductor device with one or more p-n junctions connected in series.

Rectifier-substrate assembly:	- A substrate with rectifiers placed and secured within it.
Substrate:	- Part of a multiplier module consisting of a piece of insulating material machined to accommodate the rectifiers and support the capacitor banks.

LIST OF SYMBOLS AND ABBREVIATIONS

ic	-	charging current (μA)
C_x	-	measured capacitance (pF)
D.F.	-	dissipation factor (%)
f	-	frequency (KHz)
C_i	-	input capacitance (pF)
I_L	-	load current (nA)
v_r	-	ripple voltage (V)
V_B	-	breakdown voltage (V)
V_i	-	input voltage (Vp-p)
V_o	-	output voltage (V d.c.)
η	-	efficiency (%)

1. INTRODUCTION

This Fourth Quarterly Report describes briefly the progress in the Manufacturing Methods and Techniques for Miniature High Voltage Hybrid Multiplier Modules Program, made during the period from 1 April to 30 June 1977.

In the First Quarterly Report the design and the manufacturing process for rectangular and curved multiplier modules were described. Prototype rectifier-substrate assemblies were fabricated and then redesigned to simplify the assembly operation. The specification covering the requirements for the multiplier modules forms Appendix A of the Report.

In the Second Quarterly Report results of the electrical evaluation of the first sample batch of rectangular capacitor banks TSK 25-250 and TSK 25-251 were given, the choice of the rectifier was made and electrical test results were presented on non-modular multipliers fabricated with TSK 25-250 and TSK 25-251 capacitor banks and standard HV20PD four-junction rectifiers, to evaluate these components.

In the Third Quarterly Report results of electrical tests on rectangular multiplier modules were presented. For an input voltage of 1KV, efficiencies above 96% under no-load conditions and above 95% with 500μA load currents were achieved for all multipliers assembled with TSK 25-250 and TSK 25-251 and three-chip rectifiers. Acceptable ripple voltages, input capacitances and charging currents were also measured on these multipliers. Results of the mechanical and electrical evaluation of TSK 25-249 curved capacitor banks were also presented in the Third Quarterly Report.

2. DESIGN AND CHARACTERIZATION OF THE MULTIPLIERS

2.1 Design B Multipliers

Design B multipliers were fabricated using TSK 25-254 and TSK 25-255 capacitor banks, glass-ceramic substrate assemblies and three-chip rectifiers in an attempt to optimize the multiplier structure. The lot of these multipliers made in March 1977 exhibited low output voltages and high input currents and ripple voltages.

The forward voltage drop of the diode chain was for these devices 16.5V and 21V @ 10mA, while for all other good devices it was, uniformly, 25.5V, or, 2.125V per diode. This indicates that in the first case 4 diodes were shorted and in the second 2 diodes. A visual examination of disassembled units under a microscope revealed that conductive epoxy contacts were smeared and epoxy bridges formed between some of them. The pads in TSK 25-254 and TSK 25-255 capacitors are 0.040" apart which makes alignment more critical than in the case of TSK 25-250 and TSK 25-251 where the pads are 0.050" apart.

To facilitate the assembly operation vacuum tweezers were purchased from H. Mann Inc., Huntingdon Valley, PA. The disassembled multiplier substrates were then lapped again lightly, washed, dried and assembled with new capacitors. One Design-B device could be tested only, as the substrate of the other was damaged during the operation. The device showed 96% efficiency with 5800V output voltage for 1000V input voltage, with 99% regulation and 10Vp-p ripple voltage. This series of tests, and results obtained previously, have shown that only little improvement is gained in breakdown voltage by using the capacitor banks with modified pad geometry compared with the original TSK 25-250, TSK 25-251 designs. The modified capacitor geometry is more complicated and more difficult to assemble with the substrates. It was decided to concentrate, in future work, on the original TSK 25-250 and TSK 25-251 capacitor bank pair. Two hundred pieces each of these capacitor banks were ordered from Erie Technological Products, Inc., Erie, PA., for the production of the First Engineering sample.

2.2 Impregnation and Coating of Multipliers

All the multipliers fabricated and tested in this program were not coated or encapsulated in any way. In order to avoid corona discharge, high voltage testing was done in an insulating liquid - Fluorinert FC43. Finished parts will have to be additionally protected with some kind of dielectric compound in order to meet the requirements of specification SCS-495 (see First Quarterly Report, Appendix A), specifically those relating to humidity sealing (3.2.4.3.4), mechanical shock and vibration resistance (3.2.4.3.5 and 3.2.4.3.6), and overvoltage (3.3.4). The encapsulation materials and processes have to be compatible with other processes used to fabricate the multipliers. The size constraints of the multipliers presents problems in tooling and equipment design for the final encapsulation.

The mechanical properties, position and attachment technique of the leads would make it difficult to use transfer molding for final encapsulation, which would also be prohibitively expensive for small production quantities. High process temperature and pressure could adversely affect the multipliers. Potting is rather expensive, both in terms of direct labour and in tooling-up and fabrication costs, for the casings which would have to be custom made. The case would also add to the outside dimensions of the package. Epoxy fluidized bed powder coating provides an economical way to apply uniform insulation and protective coatings 10 to 15 mil thick. It requires, however, preheating of the part to 150-200°C and a cure in the same temperature range.

All these techniques would require prior impregnation of the multiplier assembly to fill the gaps between the capacitor banks and the rectifier-substrate assembly. These gaps are a few thousandths of an inch wide and caused by the conductive epoxy, which is applied in paste form to connect the capacitor pads with the rectifier leads, and then cured. To make good contacts there must be a certain minimum amount of epoxy applied, and after the assembly step of the capacitors and the substrate the resulting structure cannot be pressed until the epoxy cures lest the epoxy squeezes out and shortens the capacitor pads. Leaving the gaps unfilled with an insulating compound would result with voltage tracking in the multiplier and would also leave the structure very fragile. It would be very advantageous if the impregnating compound could at the same time provide a conformal coating for the multiplier. Several compounds were evaluated for impregnation and coating of the multipliers. One of these materials was Mitchell Rand's R-4029 low viscosity potting compound. The compound contains mineral filler. It has a relatively high melting point and requires heating up to 163-204°C before pouring or dipping the part into it. While its softening point is between 110 and 116°C, even at room temperature the material is rather soft. Another of its drawbacks is the difficulty of obtaining thin uniform coating. We found this material unsuitable for our purpose. Further tests were done with a low viscosity, one component impregnating compound EO-0015 of Hysol (Canada) Ltd., Don Mills, Ont. This material is used at room temperature, with the parts dipped and de-aerated under vacuum, then cured over-night for 17 hrs., at 90°C. The compound has a very good penetration capability. Filling in the gaps between the substrate and both capacitor banks, it adds 0.008-0.010" per side to the thickness of the multipliers, but thinner coverage could be obtained. After curing, the parts were dipped for a second coating in the Dow Corning R-4-3117 conformal silicone resin coating, this however did not adhere well to the previous coating. Used alone to coat the parts, R-4-3117 does not penetrate the gaps completely when undiluted, and would be difficult to dry in the gaps if used diluted with xylene. Another material briefly considered but rejected because of its soft wax-like consistency, was Waterford Specialties' PC 2704 moisture resistant epoxy potting compound.

The Hysol EO-0015 which we decided to adopt is transparent and would be difficult to stamp or mark. We used red coating enamel to provide a non-transparent coverage on the multipliers.

2.3 Rectifier-Substrate Assemblies

Experiments were conducted in order to establish the optimum curing cycle of the epoxy used to pot the rectifiers in the substrate holes. The experience of silicon rectifier production shows that for high quality stable junctions the epoxy cure time and temperature are quite critical. We have tried curing the substrate assemblies at 180, 200, 225 and 240°C. Curing at 240°C resulted in carbonization of the glass-epoxy board, while curing 225°C for 16 hours did occasionally affect the substrate adversely. The curing cycle adopted for the process is:

First cure of 16 hrs., at 140°C, followed by
Second cure of 6 hrs., at 200°C

The test batches of multipliers were fabricated using 24 AWG dia silver plated copper wires soldered to the common plates of the capacitor banks with Pb 60%, Sn 38%, Ag 2% solder. The input and output terminals were made of the same type of wire bonded in specially milled grooves to the glass-epoxy substrate using conductive epoxy paste. These terminals were quite sturdy, passing 10 lb pull force tests. They added, however, 25 to 40 mils to the multiplier's thickness, which is unacceptable. In order to reduce the thickness of the multipliers a batch was assembled with 0.002" X 0.010" silver ribbon leads bonded with conductive epoxy to the capacitor pads. During lead-pull tests the joints broke at 0.25 lbs., and the leads themselves broke at a pulling force of 0.5 lbs. Silver ribbon leads .005" X 0.050" were then tested as A.C. and ground leads for rectangular multipliers. Conductive epoxy was used to bond them to the capacitor pads, but the bonds were again quite fragile: in a batch of 6 multipliers fabricated using this technique, 2 lost one lead each, after a series of tests. The ribbon leads themselves easily pass the pull-test, but the epoxy bond between the silver ribbons and the capacitor pads does not withstand the peeling-off forces during extensive handling at testing. There was no problem with leads breaking off when they were soldered and this attachment method will be used in future. In this method, leads were pretinned using Pb 60%, Sn 38%, Ag 2% solder and then soldered to the capacitors which were put on a hot plate and slowly heated on it to above the solidus temperature of the solder (350°F). This technique was used in order to avoid cracking of the capacitors, which occurred because of temperature gradients, if only soldering irons were used. Kester Solder Co., Chicago, Ill., #1544 flux was used in the process. After attaching the leads (1.5" long), the capacitors were washed first in iso-propyl alcohol, then in trichloroethylene, electronic grades, and dried in air at 120°C for 15 minutes.

Tests were made to check the multiplier's resistance to solder heat - the leads were immersed to 1/8" from the multiplier's body without heat-sinking for more than 10 secs at 500°F - exceeding the requirements of section 3.2.2.1 of SCS-495.

2.4 Multiplier Component Parts and Production Jigs

2.4.1 Rectifiers

We have standardized with RD 0058, a three-junction silicon rectifier fabricated in-house especially for this program. It is a version of our standard HV series devices modified to reduce the body length. The devices are protected by a surface passivating layer, but were not coated with epoxy. In this form some lots were stored in normal room conditions for up to 4 months after manufacturing without deterioration of characteristics. Before assemblying and potting them in the substrates they were baked for 15 minutes at 120°C and had their reverse leakages retested.

Testing of the rectifiers was done to the following limits:

Forward Voltage Drop @ I_F = 10mA	min. 1.8V max. 2.2V
Peak Inverse Voltage @ I_R = 1µA	min. 3000V
Reverse Current @ V_R = 1KV	max. 10nA

All testing is done at 25°C; during the PIV test the devices are immersed in Fluorinert FC-43, fluorochemical liquid of 3M Co., St. Paul Minn. The reverse current test is done with the devices shielded from light to eliminate the photoelectric current effects. The outline of the device is given on Fig. 1.

During the Quarter reported on, 5 lots of RD 0058 devices were manufactured totalling 1385 devices and another lot of 400 pcs., was started.

2.4.2 <u>Substrates</u>

One hundred pieces each of rectangular

TSK 312-100 and curved TSK 313-102 substrates were manufactured in our machine shop. We are soliciting quotations from outside suppliers for larger quantities of these substrates.

2.4.3 Capacitors

The TSK 25-249 curved capacitor bank forms an annular segment with a 74° arc angle. In a multiplier assembly they had to be positioned rotated by a 6° angle one against the other. This complicated the alignment during assembly and created thickness steps at the ends of the multipliers. To eliminate this a new capacitor was designed with a changed pad pattern and the arc angle increased from 74° to 80°. The drawing of the new-design capacitor is TSK 25-260 given in Fig. 2. Samples were ordered from the manufacturer, but to save time it was decided to use the mask of the previous design TSK 25-249 and screen the capacitor pads on the new body since the geometry of the pads remains the same.

Sixty-two curved capacitor banks TSK 25-260 were received on 2 June 1977.

Electrically they were not much different from the sample lot of TSK 25-240, showing an average capacitance of a double pad of 100.8 pF at no bias, which is 33 and 61% higher than the corresponding capacitance in TSK 25-250 and TSK 25-251 banks respectively. This was caused by the fact that the diameters of the pads of the curved capacitors were from 0.052 to 0.056", which exceeds both the values specified on the drawings (0.040") and those of the rectangular capacitors (from 0.043 to 0.048"). The test results are summarized in Table 1.

It was also noticed that the curved capacitors were not screened well. The pattern was offset anticlockwise in relation to the short radial edges of the bank. The dimension J (Fig. 3 and Table 2), was 0.040" instead of 0.099", and the dimension K was 0.090" instead of 0.139".

The problem with the curved capacitors was discussed with their manufacturer. They will make new screens and fabricate another lot of 100-150 parts. Delivery is expected by the end of August.

Sixty-four pairs of TSK 25-250 and TSK 25-251 rectangular capacitor banks were received on 20 May 1977. They were tested mechanically and electrically and found acceptable for multiplier assembly. Results of electrical tests of the capacitor samples are given in Tables 3 and 4.

The average capacitance per double pad of TSK 25-250 capacitors was 75.7 pF without bias, with an average dissipation factor of 0.40% and the average capacitance at 6KV was calculated from this result as 53.0 pF. For the double pads of TSK 25-251, the corresponding figures are:

$C_x(0) = 62.4$ pF   D.F. = 0.50%
$C_x(6KV) = 43.7$ pF

and for the single pads:

$C_x(0) = 23.5$ pF   D.F. = 0.18%
$C_x(6KV) = 16.4$ pF

None of the 4 capacitor banks showed a pad breaking down below 6KV, but out of 26 pads tested, 3 broke down between 6 and 7.8KV and 8 between 7.8 and 9KV.

2.4.4 Production Jigs

A jig for lapping the rectifier-substrate assemblies was designed and fabricated. It is used with a Lapmaster 12 machine of Crane Packing Co., Morton Grove, Ill. It allows simultaneous lapping of 9 curved or 12 rectangular substrates. The jig is presented on Figs. 4 and 5.

3. FABRICATION OF RECTANGULAR AND CURVED MULTIPLIERS

Thirty each rectifier-substrate assemblies were started for the First Engineering sample of rectangular and curved multipliers.

The fabrication process consists of the following steps:

1. Washing glass-epoxy substrates in iso-propyl alcohol under ultrasonic agitation, twice for 5 minutes and drying for 15 minutes at 120°C in air.
2. Cropping of diode leads at the nail head level - half on the anode side and half on the cathode side - 12 per multiplier.
3. Placement of rectifiers in substrate holes.
4. Potting with previously de-aerated epoxy compound.
5. Vacuum de-aeration, 30 minutes at a vacuum over 30 inch Hg.
6. Touch-up re-potting and cleaning the lead groove of epoxy.
7. Second vacuum de-aeration for 1 hr.
8. First temperature cure:
   16 hrs at 140°C in air.
9. Second temperature cure:
   6 hrs at 200°C in air.
10. Cropping of leads and inspection for unfilled holes, sticking-out rectifiers.

11. Lapping off excess epoxy from the bottom side of the assembly on dry #180 silicon carbide paper.

12. Mounting assemblies on lapping jigs using #70C Lakeside brand thermoplastic (quartz) cement of H. Courtright & Co., Chicago, Ill.

13. Lapping top side for 20 minutes on a Lapmaster 12 lapping machine of Crane Packing Co., Morton Grove, Ill., with Lapmaster #3900 compound suspension in #3 vehicle oil. The substrate thickness after this step is 0.060-0.065".

14. Demounting, washing, checking thickness and mounting top side down of substrate assemblies.

15. Lapping bottom side for 60 minutes - thickness should be 0.045-0.055".

16. Demounting, washing 4 times in iso-propyl alcohol and drying in air at 120°C for 30 minutes.

17. Mechanical inspection - thickness measurements, check for visible voids, diodes lapped through showing silicon wafers (evident by their rectangular shape, rather than round as for the rectifier leads) or lapped corners of silicon.

The assembly of multipliers consists of the following steps:

1. Attaching to the substrate assembly of the silver-clad copper leads gauge #28 using conductive epoxy

Epotek 410 of Epoxy Technology Inc., Watertown, Mass.

2. Curing epoxy 45 minutes at 120°C in air.
3. Attaching silver ribbon leads to the capacitor banks .005" X .050" using Pb 60%, Sn 38%, Ag 2%, solder followed by washing in iso-propyl alcohol and drying at 120°C for 15 minutes in air.
4. Mounting of the substrate assembly on one of the capacitor banks.
5. Curing epoxy as per step 2.
6. Mounting of the second capacitor bank as per step 4. In the case of rectangular multipliers the substrate is mounted on TSK 25-250 first, then TSK 25-251 is mounted on the other side of the substrate using Epotek 410 epoxy.
7. Curing epoxy as per step 2.
8. Testing the multiplier for rectifier chain continuity. Forward voltage drop at 10mA and 25°C should be 25.5 ±0.5V.
9. Impregnation with EO-0015 single component impregnating and casting system of Hysol Division, The Dexter Corporation, Olean, N.Y. The process is done in better than 30" Hg vacuum for 3 hours, or until bubbling stops.
10. Curing epoxy 15 hrs at 130°C followed by 2 hrs at 150°C.

11. Air-spraying with red enamel.

12. Drying in air for 1 hr.

13. Repeat of step 11.

14. Drying in air for 3 hrs.

15. Baking at 150°C for 15 hrs.

16. Cleaning impregnating epoxy and paint off leads.

17. Tinning leads with Pb 60%, Sn 38%, Ag 2% solder.

18. Marking.

Out of 30 rectangular substrates 4 were rejected; they were replaced with 7 pieces made previously. Total labour was 1025 minutes, or 43 minutes per assembly.

Of the 30 curved substrates, 4 were found non-acceptable. The labour was cut down to 660 minutes or 27 minutes per assembly - thanks to more experience and better skills of operators.

Thirty-three rectangular multipliers were assembled. When tested for diode-chain FVD before impregnation:

(a) 23 were found good with FVD of 25.5V;

(b) 1 was rejected with FVD of 31.5V;

(c) 5 showed open circuit;

(d) 4 showed low FVD of 21 (3 pcs.) and 17V (1 pc.) indicating 2 or 4 diodes shorted respectively.

Multipliers of groups B and D were scrapped. Those of group C had the capacitor bank that was attached last (i.e. TSK 25-251), taken off with a razor blade. They were then lapped slightly, washed in iso-propyl alcohol dried and were re-assembled. Of these 5 pieces, 2 were good after this re-work, but 3 broke mechanically.

To these, 3 pcs., were added from a lot fabricated in May with ribbon leads attached not with solder, but with conductive epoxy.

Leads of 2 multipliers were broken while scraping the epoxy off.

Twenty-six rectangular multipliers were transferred for First Engineering Sample Testing. The labour put into making them was 30 hrs., or 1.15 hr., a piece.

Fifteen curved multipliers were assembled. They all showed open circuit condition when tested for continuity. This was due to misalignment of the screened pattern as discussed in Section 2.4.3.

Seven curved multipliers were then assembled using the remaining substrate assemblies and TSK 25-249 capacitors (with the angle of 74^{0}.) Of these, one was found open-circuited and was damaged in an attempt to disassemble it, and two showed open circuit condition after impregnation coating, although they were good before these operations. The remaining 4 devices were transferred to Q.C., for testing.

4. CONCLUSIONS

With the capacitor design finalized, the coating technique developed, and the choice of the lead material and attachment technique made, we were able to proceed to fabricating the First Engineering Samples.

The rectangular multipliers were finished and will now undergo electrical testing.

Of the curved multipliers only 3 will be tested, as the others were scrapped due to problems with capacitor pad's geometry.

5. PROGRAM FOR NEXT QUARTER

1. Test 26 rectangular and 4 curved multipliers to the First Engineering Sample requirements.

2. Test a small lot of rectangular multipliers to the Second Engineering Sample requirements.

3. Order a new lot of curved capacitor banks and substrates and fabricate 25 curved multipliers.

4. Submit the First Engineering Sample.

5. Secure an outside supplier for epoxy-glass substrate and order a sample quantity.

6. PUBLICATIONS AND REPORTS

No reports or publications were made on the work associated with this program during the current quarter.

7. IDENTIFICATION OF PERSONNEL

Brief descriptions of the background of technical personnel involved were included in the preceding Quarterly Progress Reports. Background of personnel added to the program during the fourth quarter follows:

During the fourth quarter of the program the following persons worked in their area of responsibility:

INDIVIDUAL	RESPONSIBILITY	HRS. SPENT
Dr. M. Korwin-Pawlowski	Program Manager	169
G. Gordon	Senior Electronic Engineer	98
D. Platt	Manager, Quality Assurance and Control, High Voltage Products	11
D. Archard	Senior Test Technician	10
V. Glenn	Q.C. Inspector	40
C. Grills	Senior Engineering Technician	51
L. Macklin	Draftsman	185
D. Regan	Senior Engineering Technician	20
F. Treverton	Senior Test Technician	54

L.E. MACKLIN Draftsman

PROGRAM RESPONSIBILITY:

Preparation of drawings on components and assemblies of the voltage multiplier modules.

CURRENT ASSIGNMENT:

Prepares prints on components and assemblies of the various High Voltage multiplier and power supplies designed and produced by the High Voltage Engineering Department.

ACADEMIC AND PROFESSIONAL BACKGROUND

Completed 4 year Science, Technology and Trades course in Electrical Drafting; Brighton High School, 1971.

Received Honours Diploma as an Electrical Engineering Technician (Dean's List); Loyalist College, 1973.

Taken and passed evening courses in Electronics and Drafting (Loyalist College, 1975 & '76) and Mechanical Drafting and Blueprint Reading (Loyalist College, 1977).

1974 - present	Employed as Draftsman by Erie Technological Products of Canada, Ltd.
1973 - 1974	Draftsman with E.S.B. Willson Canada, Ltd., Trenton, Ontario.

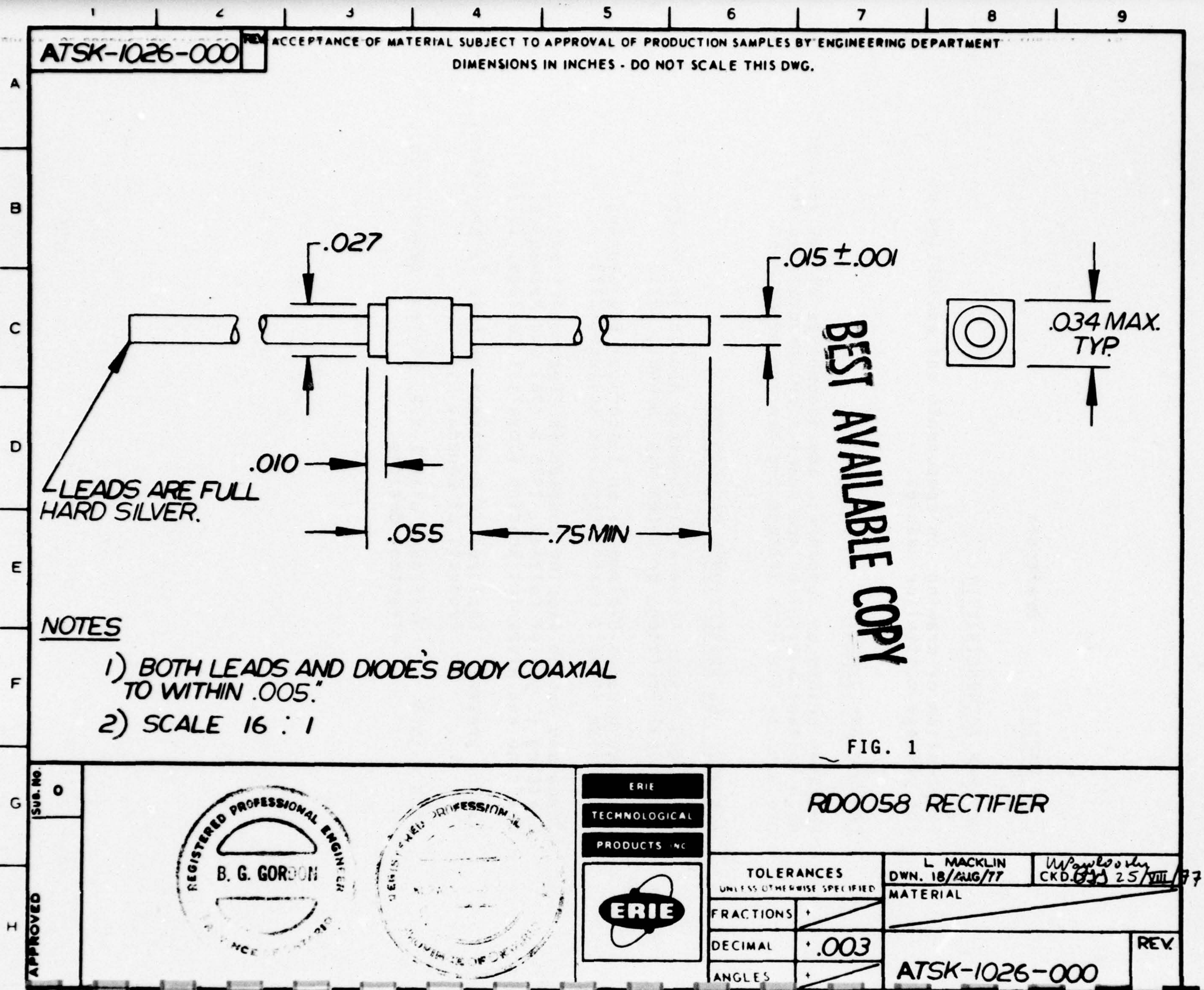
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FIG. 1

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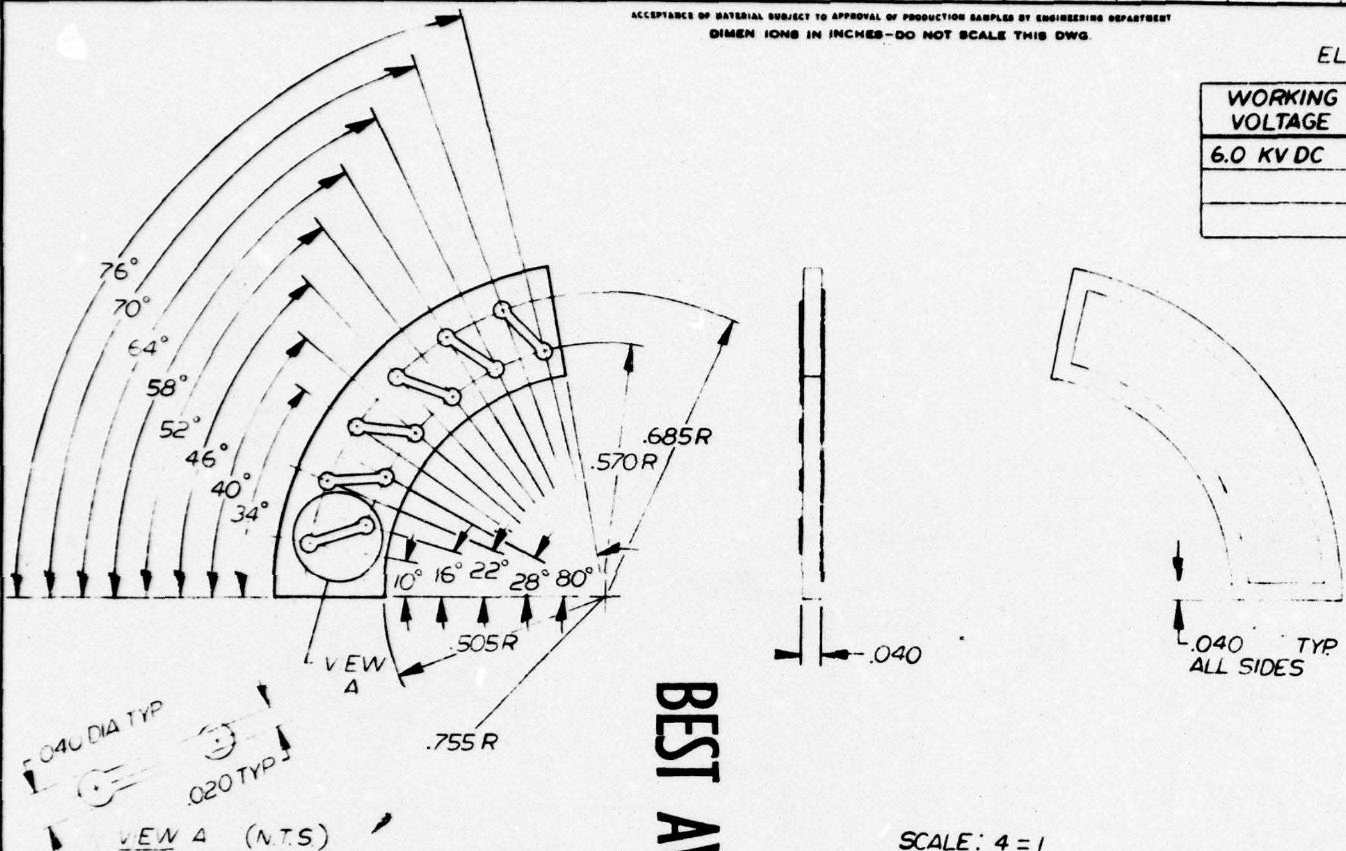
DIMENSIONS IN INCHES—DO NOT SCALE THIS DWG.



SCALE: 4 = 1

ELECTRICAL SPECIFICATION

WORKING VOLTAGE	OPERATING TEMPERATURE	CAP. (pF) + TOL./SECT.
6.0 KV DC	+25°C	(5 pF ± 20%

1.2 TEMPERATURE CHARACTERISTIC (X5R)

1.3 DIELECTRIC STRENGTH TEST VOLTAGE 9.0 KV AT 25°C.

1.4 INSULATION RESISTANCE AT TEST VOLTAGE (+25°C) 100 KM OR 1000MΩ μF.

1.5 CAPACITANCE AT 25°C, 1 KHz, 1VRMS AND WORKING VOLTAGE - (SEE TABLE ABOVE).

1.6 D.F. UNDER SAME CONDITION AS REF. 1.5 SHOULD BE <2.5%

1.7 SCHEMATIC

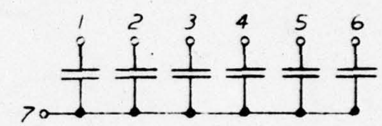


FIG. 2

PARALLEL BANK CAPACITOR (MOD. #2)

ERIE TECHNOLOGICAL PRODUCTS

TOLERANCES UNLESS OTHERWISE SPECIFIED	
FRACTIONS	·
DECIMAL	.002
ANGLES	· 0°30'

DWN. L. MACKLIN 6/MAY/77
CKD.
MATERIAL

BTSK-25-260 REV.

BTSK-25-260 REV.

ACCEPTANCE OF MATERIAL SUBJECT TO APPROVAL OF PRODUCTION SAMPLES BY ENGINEERING DEPARTMENT
DIMENSIONS IN INCHES—DO NOT SCALE THIS DWG.

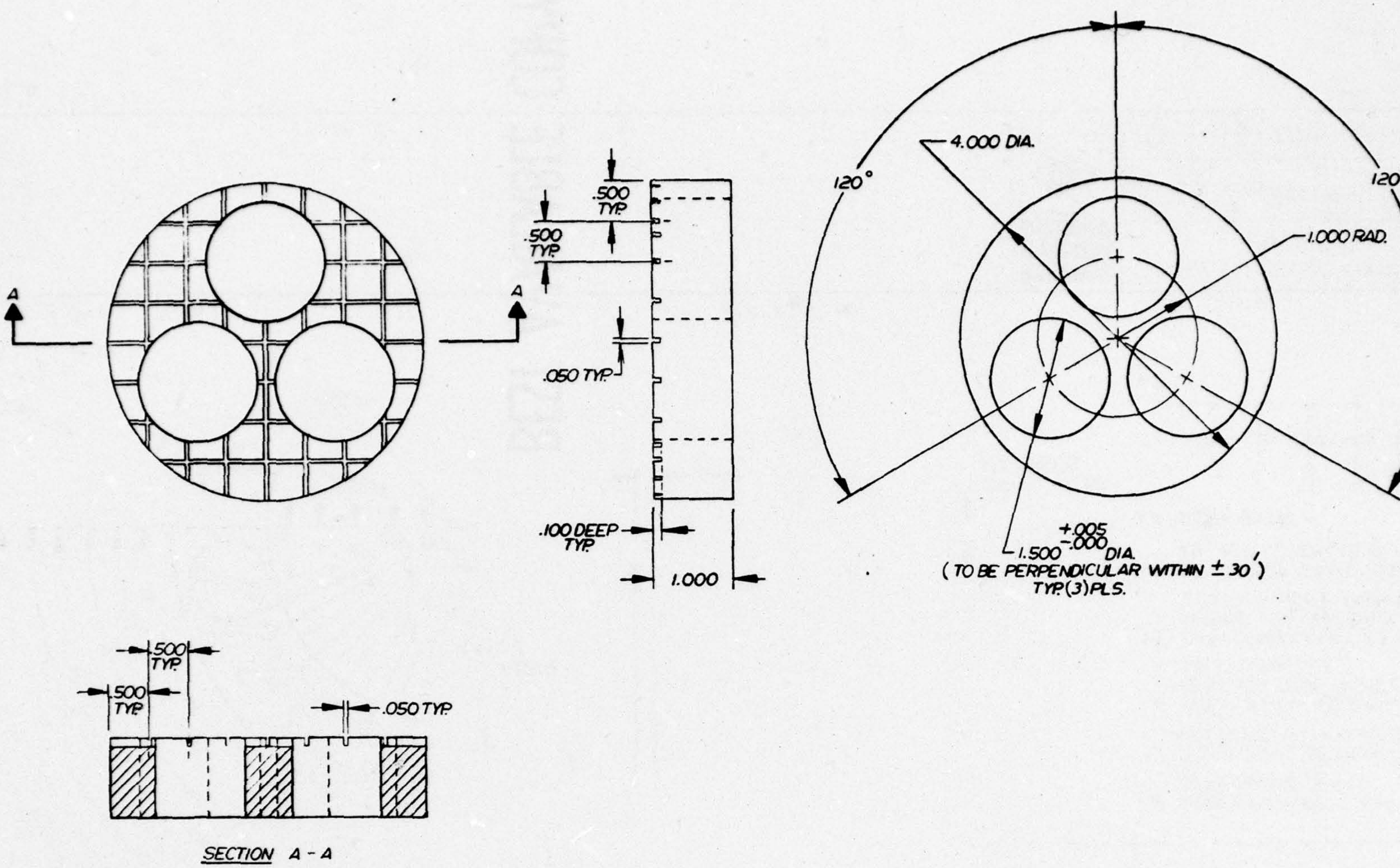


FIG. 4

SUBSTRATE
LAPPING FIXTURE

TOLERANCES UNLESS OTHERWISE SPECIFIED	DWN. L. MACKLIN 19/AUG/77	CKD. 25/VIII/77
FRACTIONS ±	MATERIAL: HARDENED STEEL	
DECIMAL ± .020	CTEX-1015-300	REV.
ANGLES ± 1°		

CTEX-1015-300 REV

B. G. GORDON
REGISTERED PROFESSIONAL ENGINEER
PROVINCE OF ONTARIO

ERIE

APPROVED

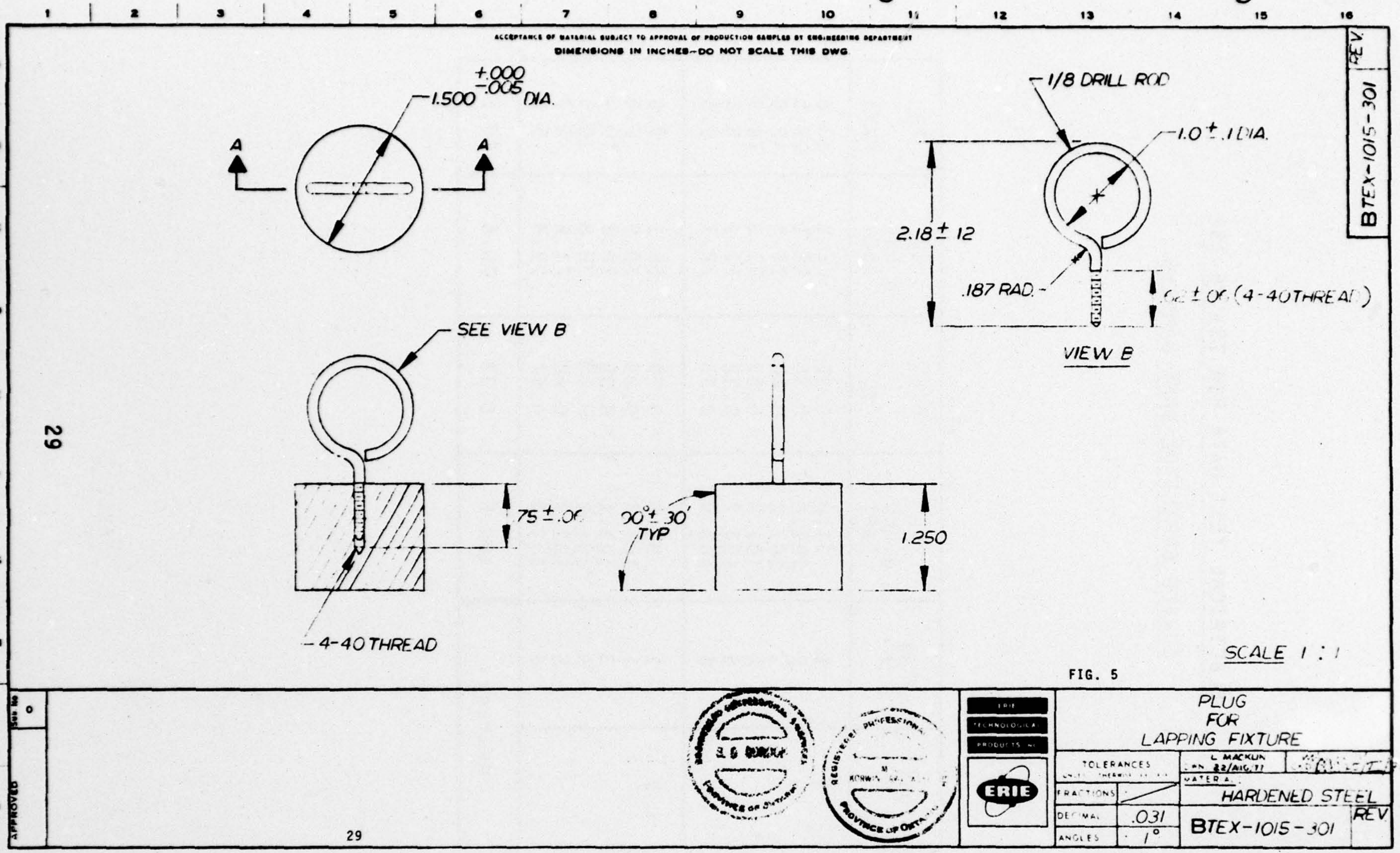

ACCEPTANCE OF MATERIAL SUBJECT TO APPROVAL OF PRODUCTION SAMPLES BY ENGINEERING DEPARTMENT
DIMENSIONS IN INCHES—DO NOT SCALE THIS DWG.
1.500 +.000 -.005 DIA.
A
A
1/8 DRILL ROD
1.0 ± .1 DIA.
2.18 ± 12
.187 RAD.
.62 ± .06 (4-40 THREAD)
VIEW B
SEE VIEW B
75 ± .06
90° ± 30' TYP
1.250
4-40 THREAD
SCALE 1 : 1
PLUG FOR LAPPING FIXTURE
TOLERANCES
FRACTIONS
DECIMAL .031
ANGLES 1°
L. MACKLIN
22/AUG/77
MATERIAL
HARDENED STEEL
BTEX-1015-301
REV
ERIE
ERIE TECHNOLOGICAL PRODUCTS
APPROVED
0
REV.
BTEX-1015-301

FIG. 5

ELECTRICAL TEST DATA FOR TSK 25-260

CURVED CAPACITOR BANK SAMPLES

UNIT #	PAD #	C_x @ 0kV (pF)	D.F. (%)	C_x @ 6kV (pF)	V_B (kV)
1	1	94.0	0.35	65.8	13.5
	2	105.8	0.36	74.1	12.5
	3	107.2	0.40	75.0	12.6
	4	101.8	0.37	71.3	14.9
	5	104.2	0.38	72.9	8.5
	6	103.9	0.38	72.7	9.5
2	1	83.0	0.29	58.1	9.0
	2	101.3	0.39	70.9	7.6
	3	101.1	0.39	70.8	10.9
	4	101.2	0.40	70.8	10.5
	5	102.3	0.40	71.6	8.7
	6	103.4	0.41	72.4	9.0
Average		100.8	0.33	70.6	10.6

TABLE 1

TSK 25-260

DIMENSIONING OF CURVED BANK CAPACITORS

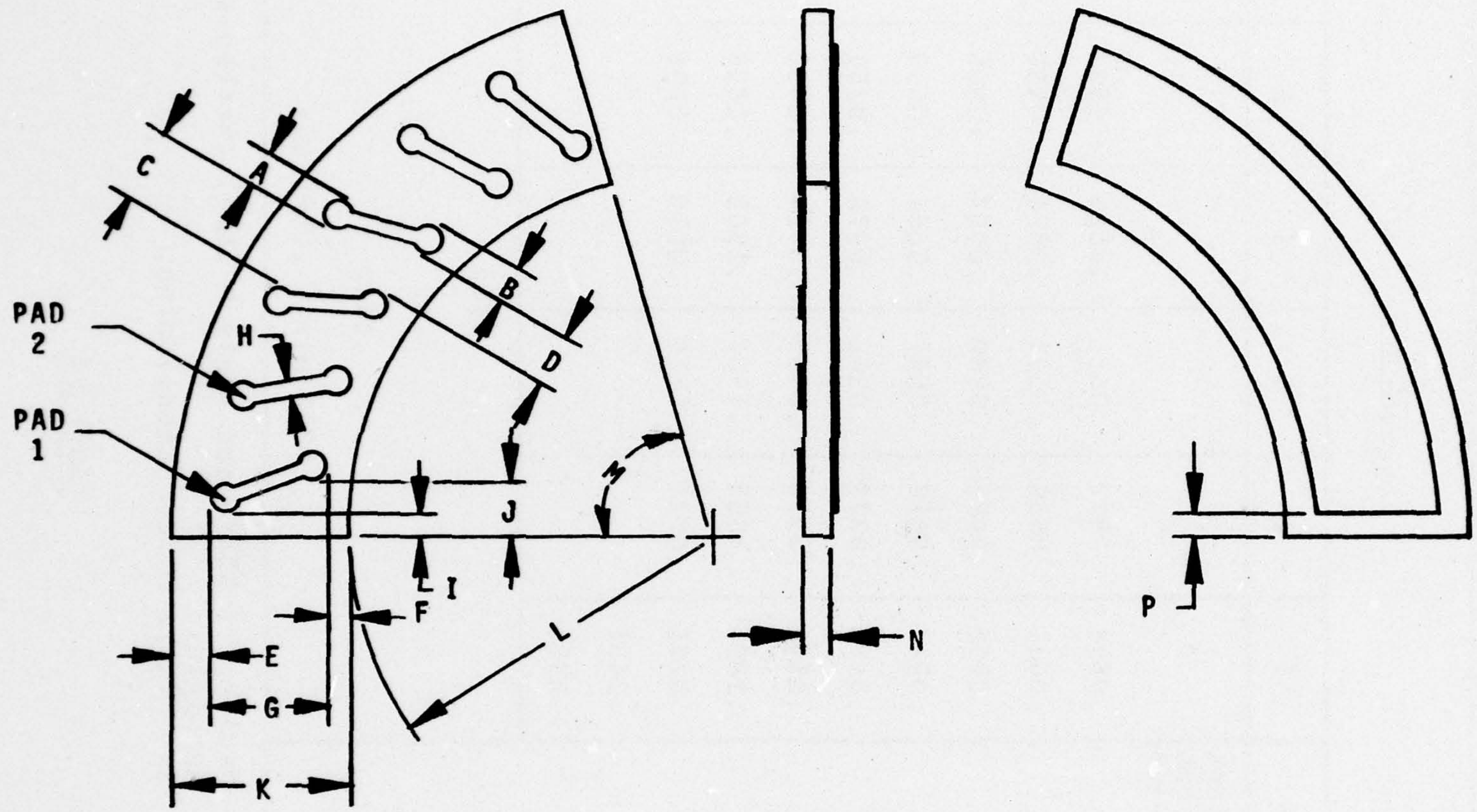


FIG. 3

MECHANICAL INSPECTION DATA FOR TSK 25-260 CAPACITOR BANKS

UNIT 1

PAD #	`1	2	3	4	5	6
Dimensions in inches						
A	.0521	.0522	.0523	.0525	.0531	.0529
B	.0518	.0536	.0531	.0524	.0539	.0523
C	.0912	.0925	.0900	.0907	.0905	
D	.0647	.0656	.0647	.0661	.0658	
E	.0396	.0377	.0366	.0374	.0351	.0398
F	.0365	.0373	.0409	.0424	.0450	.0460
G	.1895	.1895	.1907	.1902	.1898	.1892
H	.0235	.0221	.0228	.0210	.0236	.0240
I	.0401					.1740
J	.0901					.0799
K	.2469					
L&M	O.K.					
N	.0440					
P	.0214 min., .0804 max.					

NOTE: Radius L (.505") and angle M (80^0) checked against template.
See Figure 3 for dimensioning.

TABLE 2A

MECHANICAL INSPECTION DATA FOR TSK 25-260 CAPACITOR BANKS

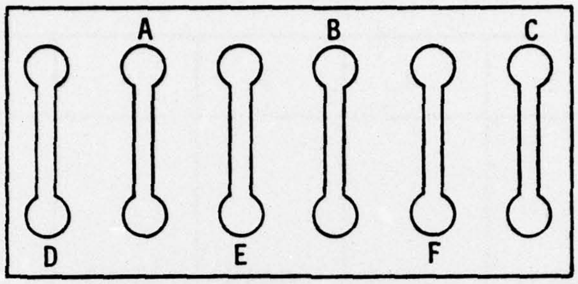
UNIT 2

PAD #	1	2	3	4	5	6
Dimensions in inches						
A	.0557	.0533	.0546	.0554	.0560	.0530
B	.0546	.0538	.0540	.0553	.0543	.0566
C	.0900	.0904	.0883	.0886	.0908	
D	.0629	.0669	.0609	.0645	.0624	
E	.0482	.0445	.0386	.0367	.0321	.0301
F	.0232	.0257	.0305	.0357	.0392	.0415
G	.1898	.1925	.1897	.1908	.1938	.1902
H	.0253	.0237	.0257	.0250	.0287	.0280
I	.0404					.1684
J	.0896					.0734
K	.2452					
L&M	O.K.					
N	.0440					
P	.0163 min., .0794 max.					

NOTE: Radius L (.505") and angle M (80°) checked against template.
See Figure 3 for dimensioning.

TABLE 2B

CHARACTERISTICS OF TYPE TSK 25-250 CAPACITOR

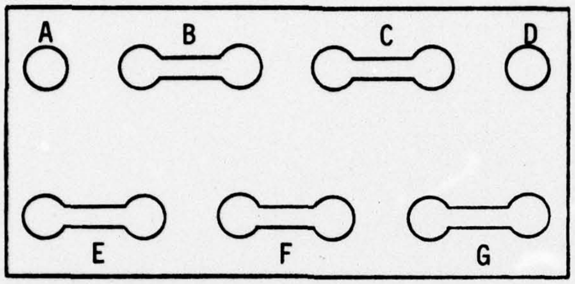


Bottom Pad Grounded

UNIT	PAD	C_x @ no bias (pF)	D.F. (%)	C_x @ 6kV (pF)	V_B (kV)	FLASH-TEST @ 9kV
1	A	86.7	0.48	60.7	9.0	FAIL
	B	88.6	0.48	62.0	9.0	FAIL
	C	56.1	0.36	39.3	14.4	O.K.
	D	52.1	0.26	36.5	10.0	O.K.
	E	88.6	0.62	62.0	7.0	N/A
	F	87.8	0.62	61.5	8.8	N/A
2	A	82.7	0.38	57.9	7.4	N/A
	B	85.6	0.34	59.9	8.6	N/A
	C	56.8	0.20	39.8	9.0	N/A
	D	50.3	0.23	35.2	9.0	FAIL
	E	86.0	0.40	60.2	9.0	FAIL
	F	86.5	0.41	60.6	8.8	N/A

TABLE 3

CHARACTERISTICS OF TYPE TSK 25-251 CAPACITOR



Bottom Pad Grounded

UNIT	PAD	C_x @ no bias (pF)	D.F. (%)	C_x @ 6kV (pF)	V_B (kV)	FLASH-TEST @ 9kV
1	A	23.7	0.19	16.6	9.4	O.K.
	B	69.0	0.69	48.3	6.0	N/A
	C	65.7	0.64	46.0	9.0	FAIL
	D	23.6	0.22	16.5	9.0	FAIL
	E	57.4	0.59	40.2	12.4	O.K.
	F	65.3	0.57	45.7	8.2	N/A
2	A	23.0	0.17	16.1	15.0	O.K.
	B	63.7	0.48	44.6	9.0	N/A
	C	64.0	0.42	44.8	10.6	O.K.
	D	23.5	0.13	16.5	8.6	N/A
	E	56.2	0.35	39.3	10.6	O.K.
	F	68.2	0.39	47.7	9.0	O.K.

TABLE 4

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